THE SUPPORTING AND COUNTERWEIGHTING OF THE PRINCIPAL AXES OF LARGE TELESCOPES.*

By C. D. Perrine.

In a telescope whose moving parts weigh several tons it is desirable to reduce the friction in the bearings as much as possible. This is particularly true in the case of the polar axis, which must be driven by a clock at a very regular rate.

The practice has been to have the axis revolve in fixed boxes, usually lined with Babbitt metal, and to relieve the greater part of the pressure by a system of friction-wheels which are pressed upward against the axis, near the bearing, by suitable weights and levers. This is in effect transferring the pressure to smaller surfaces having slower motions. In some cases a ring of rolls has been used in connection with levers and weights. These systems have reduced the friction materially.

In designing the driving-clock of the new mounting for the Crossley reflector of the Lick Observatory I used a simple form of roller-bearing for the drum-shaft and the next two shafts in the train. This form of bearing was not adopted until after an experimental trial, which resulted most satisfactorily. The admirable performance of these bearings has suggested the suitability of this principle for the axes of large telescopes, particularly the polar axes.† Such bearings would do away with the necessity of any auxiliary system of counterweights, and I have reason to believe that, with proper construction, the friction would be less than with the best of the counterweighted systems. As to their accuracy and freedom from play, there should be no difficulty, judging from those already tried. These fit closely, there is no looseness whatever, and the shaft turns with perfect ease and smoothness.

The construction is simple. There is no frame to hold the rolls in fixed relative positions. The rolls are placed in the

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† It was not possible to adopt this system in the new telescope-mounting, as the heavy parts had already been constructed.

bearing and are kept from falling out by plates fastened to the body of the bearing. The rolls should fit snugly, but not so closely as to introduce appreciable friction between the elements of their surfaces which are in contact. The ends of the rolls should be beveled slightly, away from the center, leaving only a small surface or knob to come into contact with the plate. The rolls should be of steel, hardened and ground accurately round and to uniform diameters. The shaft should of course be of steel, accurately turned and ground. The bearing should be lined with a shell of steel to form the other rolling surface, although close-grained cast-iron makes a very good surface.

The dimensions of the shaft and rolls should be such that there will be not less than fifteen of the latter, thus always having several rolls which are taking the weight. There will then be less tendency for the rolls to jam or the shaft to settle between two of them. The latter condition would be fatal to the working of the system. If the rolls were long, it is probable that they would work more smoothly if cut into sections.

There is perhaps no more satisfactory way of taking the thrust of a large polar axis than that in common use—a balanced plate and one or two rings of balls.

When the parts which move in declination weigh not over four or five tons, the declination-axis performs very well with Babbitted bearings, the thrust being taken by steel shoulders and collars working against Babbitt. Such axes would, however, move much more easily with rolls, and balls to take the thrust. In large instruments a reduction of the friction of this axis is necessary.

The system of roller-bearings here suggested would be fully as efficient in the case of a large overhang of the polar axis as in the ordinary form of mounting.

If the polar axis is supported on two separate piers, the bearings are entirely independent of each other, and some means of aligning the bearings must be provided. It has usually been the custom in such cases to make the bearing in two parts: a lower section with a broad base, and the usual cap. By providing the lower half with screws for leveling and for lateral adjustment the necessary alignment can be secured. It is, however, an advantage to have the bearings self-aligning. This can be accomplished by making the lower

half of the bearings in two parts which fit together on cylindrical surfaces, the axis of these cylindrical surfaces being at right angles to the polar axis and passing through the center of the bearing. Lugs and holding-bolts serve to keep the two portions together. This device allows the bearings to adjust themselves, in altitude, to the polar axis. The adjustment of the bearings to the axis in azimuth can be accomplished by having a stout pin on the under side of the lowest section of the bearing, which turns in the base-plate. Such a system would make the bearing a universal joint through small arcs, and wholly self-aligning. Bolts for holding the bearing to the pier should of course be provided.

The bearing at the lower end of the polar axis can be made to take the thrust and at the same time be wholly self-aligning. This may be done by extending the cylindrical portions upward around the end of the axis so as to contain the line of thrust.

When both ends of the axis are supported from the same base-casting, the bearings are usually fixed. Even in that case there would probably be some advantage in using self-aligning bearings.

While the subject of this paper properly belongs to a different Section of the Association, it is perhaps of special interest to astronomers.

MT. HAMILTON, CALIFORNIA, November 30, 1903.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1904.

BY MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

Last Quarter,	May	7,	$3^h 50^m$ A.M.	Last Quarter,	June	5,	$9^h 53^m$ P.M.
New Moon,	"	15,	2 58 A.M.	New Moon,	"	13,	1 10 P.M.
First Quarter,	"	22,	2 19 A.M.	First Quarter,	"	20,	7 11 A.M.
Full Moon,	"	29,	12 55 A.M.	Full Moon,	"	27,	12 23 P.M.

The Sun reaches the solstice and summer begins on June 21st at about 1 P.M., Pacific time.

Mercury on May 1st is an evening star, setting about an hour and one half after sunset. It passed greatest east elonga-